

Ensemble Learning Breast Lesion Classification based on Magnetic Resonance Spectroscopic Imaging and Diffusion-Weighted Imaging

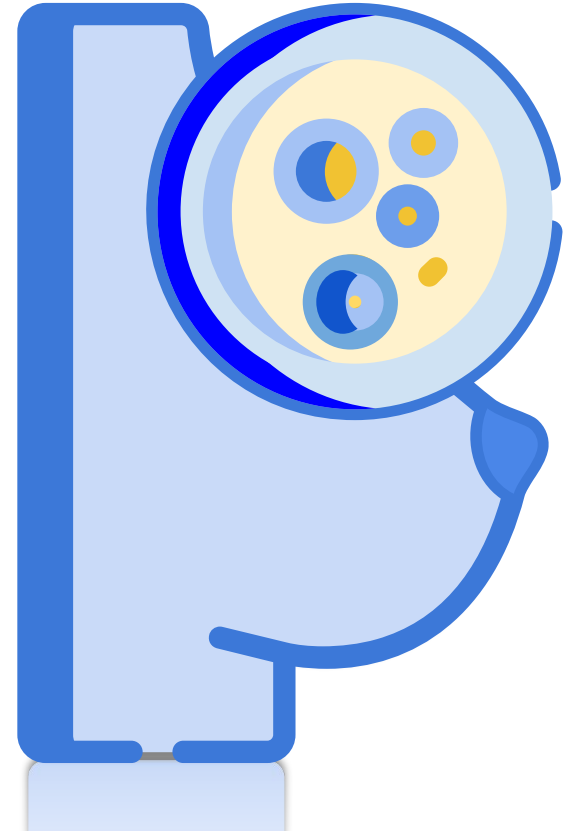
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Breast cancer early detection

- Lifetime risk of 12.92% and approximately 297,790 new cases to be diagnosed in females in the U.S. in 2023
- Early detection of malignancy before metastasis improves treatment outcomes
- Small sizes and slow proliferation of early tumors — difficult to detect



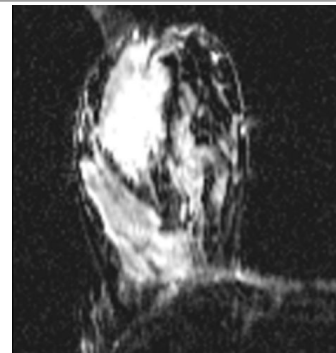
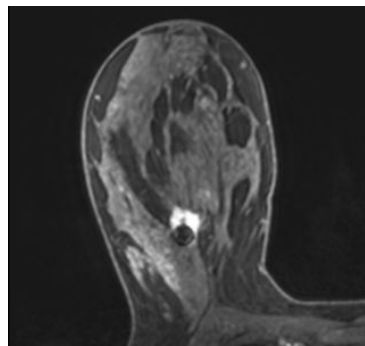
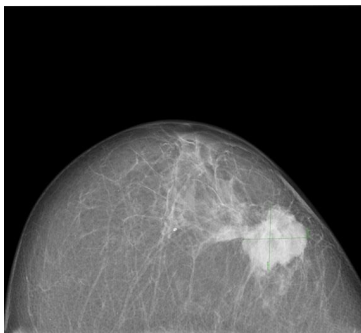
Existing Techniques

X-ray based

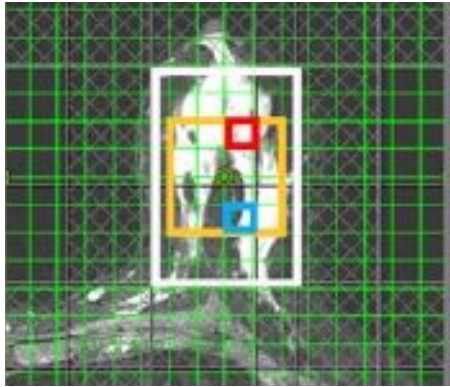
Magnetic Resonance Imaging (MRI) based

Mammography	Dynamic-contrast Enhanced MRI (DCE-MRI)	Diffusion-Weighted Imaging (DWI)
<ul style="list-style-type: none"> · Gold Standard · Fast Scanning 	<ul style="list-style-type: none"> · High sensitivity 	<ul style="list-style-type: none"> · High sensitivity in conjunction with DCE-MRI
<ul style="list-style-type: none"> · Increased false findings · Use ionizing radiation 	<ul style="list-style-type: none"> · Wide range of specificity · Contrast potentially harmful 	<ul style="list-style-type: none"> · Wide range of specificity · Not protocol for breasts

Multiparametric MRI (mpMRI)



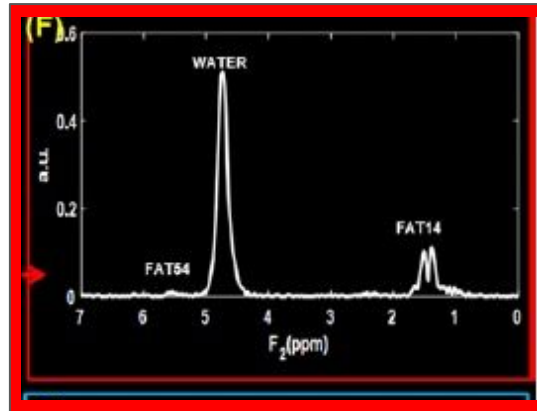
Magnetic Resonance Spectroscopic Imaging (MRSI)



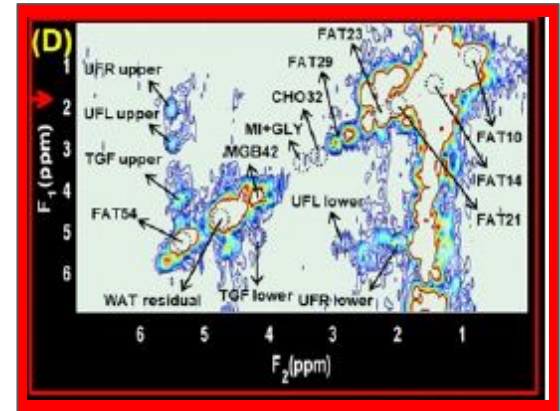
benign

Volume-of-interest
(VOI) placement

1D Spectra



2D Spectra



A pilot study

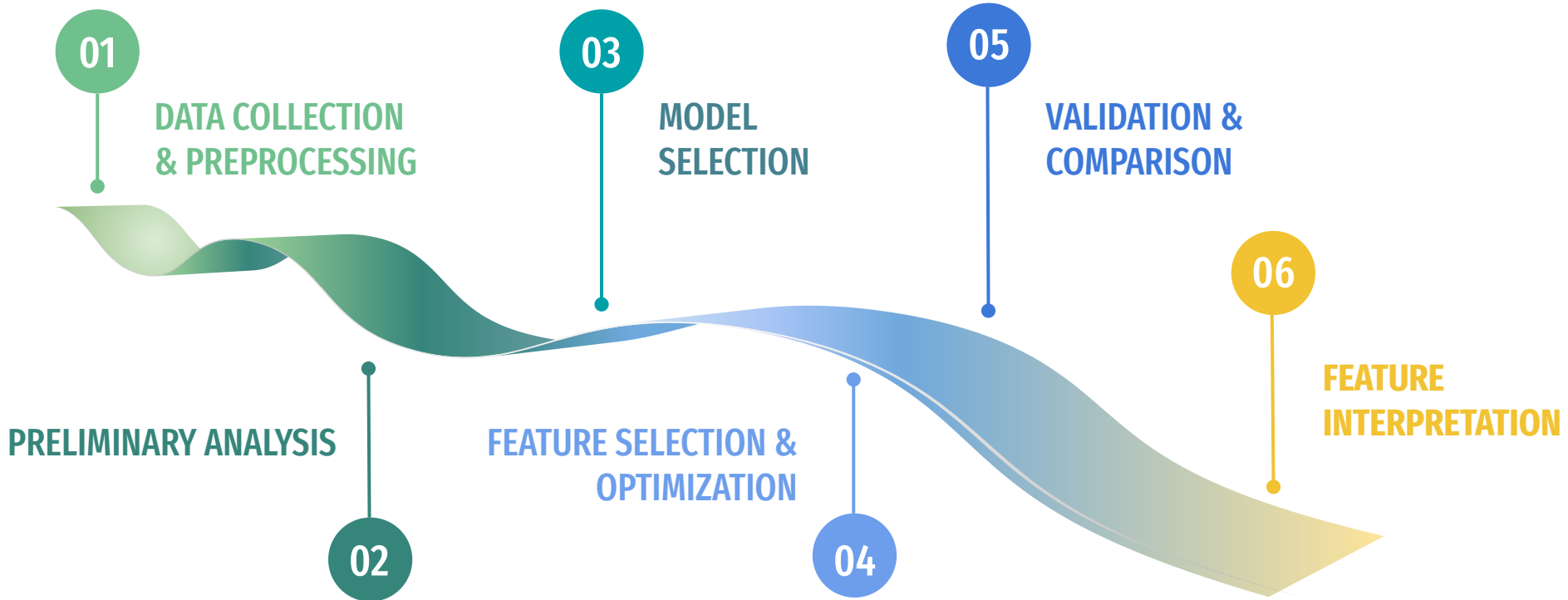
Evaluate the practicality of using MRSI + DWI features in breast lesion classification

Classifiers: - Machine Learning Classifiers

Outcomes: - Benign and malignant breast tumor classification

- Interpret model outcomes and significant features - cancer biology

Methods - Overview



Classification Model Selection

Individual Model

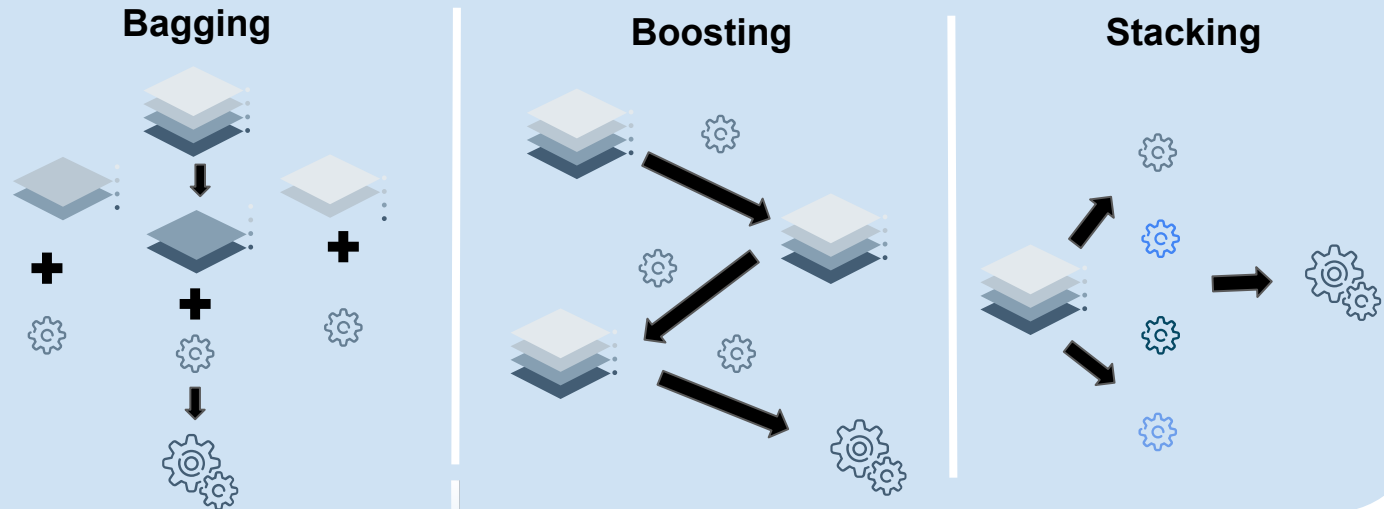
Support Vector Machine

K-Nearest Neighbors

Decision Tree

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Ensemble Learning



Results - Data and Features

DWI - radiomic feature extraction

- Apparent Diffusion Coefficients Maps from Diffusion-Weighted Imaging

MRSI - metabolite ratio quantitation

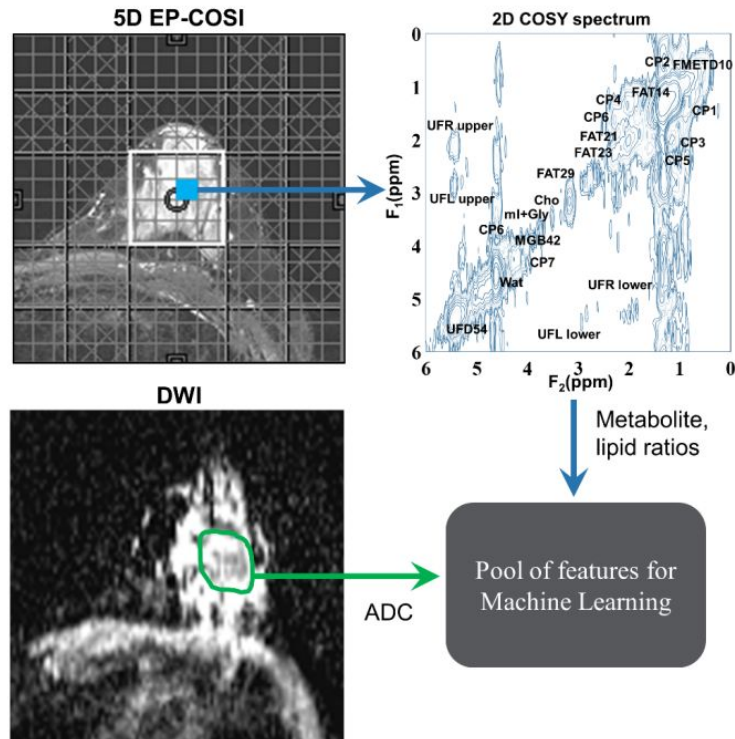
- 24 Metabolites are quantitated w.r.t. 4 ratios
- 1D water, fat fraction and unsaturation index

Statistical tests of differences + Recursive Feature Elimination

Lipid cross-peaks & diagonal peaks
from the 2D spectra + ADC

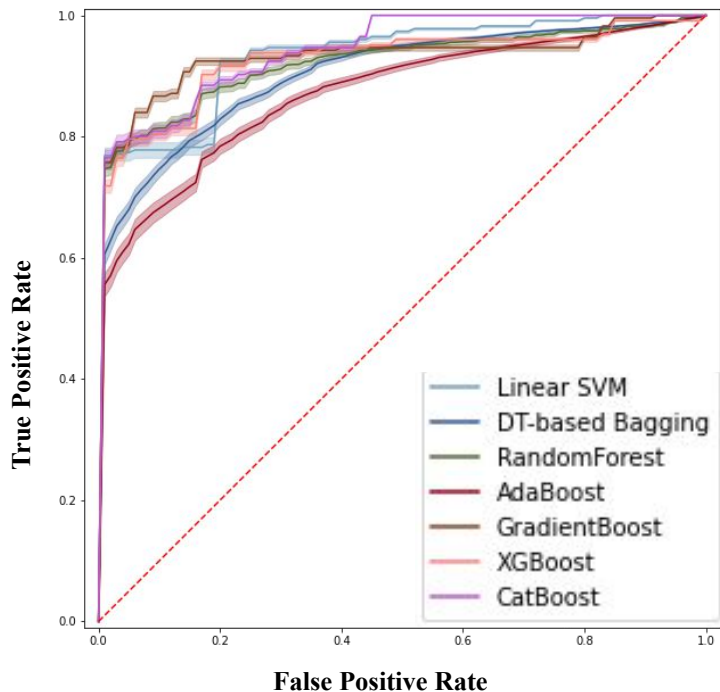
Correlation Analysis

- Examine potentially redundant variables
- Reduce the chance of model overfitting

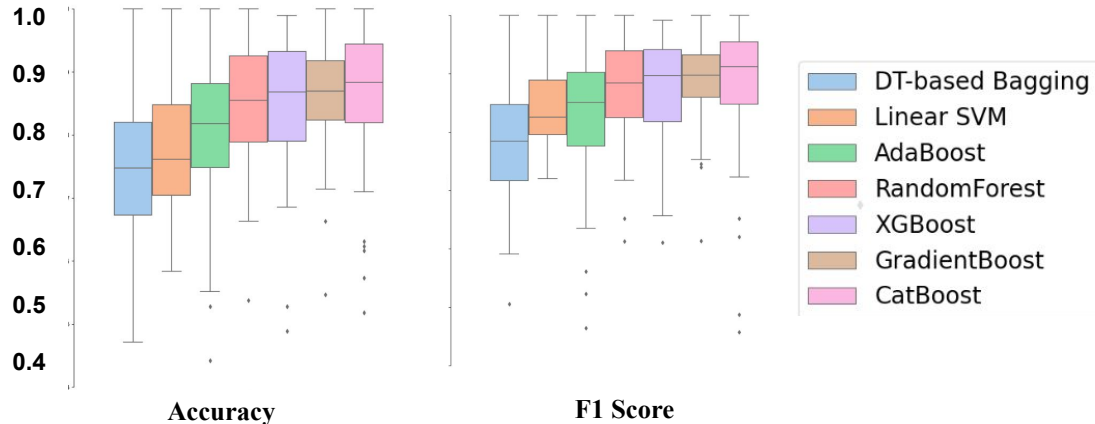


Results - Models

ROC curves for the final models



Testing Scores



Models \ Metrics	Extreme Gradient Boost	Categorical Boost	Gradient Boost
Accuracy	86% ± 9.6%	87% ± 9.6%	87% ± 7.9%
F1 Score	88% ± 8.6%	88% ± 9.9%	89% ± 6.7%

Conclusion

MRS Data

- **Demonstrated** that 2D spectra + ADC values could be used to build ML Classifiers for malignant v.s. benign breast lesion

Feature Importance

- **Identified** multiple cross-peaks from 2D correlated spectroscopy spectra as important features for the ML classification
- **Showed** advantage of two spectral dimensions over one

Model Performance

- **Built** Gradient Boost-based classifiers with performance comparable to existing methods.



References

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